86757

S/120/60/000/006/033/045
E032/E314

On the Rate of Growth and the Rate of Upward Drift of Bubbles in a Propane Chamber

The errors indicated represent maximum deviations. According to Plesset and Zwick (Ref. 4), the constant C for propane has the theoretical value of 0.17. The rate of upward drift for the above range of bubble radii was found to be 0.036 and 0.117 mm/sec. It is clear that the rate of upward drift is appreciably greater than the rate of growth of the bubbles, i.e. during its growth each bubble is displaced through the surrounding medium. This fact was not taken into account by Seitz (Ref. 3). The heat exchange between the bubble of liquid, which determines its rate of growth, will be greater in the case of a moving bubble. This will lead, in the case of the present experiment, to a discrepancy between experiment and theory, as indicated above. Further work is being carried out in this connection.

X

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E032/E314

On the Rate of Growth and the Rate of Upward Drift of Bubbles in a Propane Chamber

There are 1 figure and 4 references: 2 Soviet and 2 English.

ASSOCIATIONS: Fizicheskiy institut AN SSSR
(Physics Institute of the AS USSR)
Moskovskiy fiziko-tekhnicheskiy institut
(Moscow Physico-technical Institute)

SUBMITTED: September 29, 1959

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86756

S/120/60/000/006/032/045
E032/E314

21.5200 (1033, 1144, 1191)

AUTHORS: Aleksandrov, Yu.A., Delone, N.B., Likhachev, V.M. and Gorbunkov, V.M.

TITLE: Formation of the Image in the Photography of Bubble-chamber Tracks

PERIODICAL: Pribory i tekhnika eksperimenta, 1960, No. 6, pp. 118 - 119

TEXT: It was shown in Ref. 1 that when bubble-chamber tracks are photographed, the object which is actually photographed is the virtual image of the source in the bubbles. The refractive index of the vapour in the bubble is smaller than the refractive index of the surrounding liquid and hence the bubble is divided into two zones. The bubble constitutes a negative lens for rays incident at angles smaller than the angle of the total internal reflection, and a convex spherical mirror for rays incident at angles greater than the angle of total internal reflection. This is illustrated in Fig. 1. The point source S_o is located at infinity on the left of

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Formation of the Image in the Photography of Bubble-chamber Tracks

the bubble. The ray 1 is refracted, while the ray 2 is reflected. Intermediate rays having angles of incidence $i_1(i_2)$ have the corresponding values of $h_1(h_2)$ and $\varphi_1(\varphi_2)$. They form virtual images $S'_{01}(S'_{02})$ of the source S_o on the axis S_oO'. Both for the refracted and reflected rays we have

$$h_{1|(2)} = r \sin i_{1(2)}, \quad h_{1(2)} = H_{1|(2)}$$

while for the refracted rays we have

$$\varphi_1 = 2(i'_1 - i_1) \quad \text{and} \quad n_{ж} \sin i_1 = n_{п} \sin i'_1$$

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Formation of the Image in the Photography of Bubble-chamber Tracks

where n_* is the refractive index of the liquid and

n_π is the refractive index of the vapour.

For the reflected rays $\varphi_2 = 2(90^\circ - i_2)$. The objective of the photographic camera receives a narrow pencil of rays whose aperture is defined by the diameter of the entrance pupil of the objective and the distance to the working volume of the camera. For an objective with a focal length of 50 mm, a relative power of 1:20 and a distance to the working volume of 500 mm, the aperture of the pencil is about 0.5°. It follows that the image formed by the objective is due only to a very narrow pencil of rays. Such a pencil will experience only paraxial aberrations, i.e. astigmatism and distortion. In order to confirm the above theory of image formation, an expriment was carried out using two sources of light located symmetrically with respect to the objective-bubble axis. In this geometry each bubble forms four virtual images, two of

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which are produced by the refracting zone and two by the reflecting zone. The distance between each corresponding pair of images, which is equal to $2H_1$ and $2H_2$ in the two cases, respectively, depends on the radius of the bubble. For all bubbles, $2H_2$ is determined by the relative refractive index of the liquid and the vapour $n_{ж}/n_{п}$. In the experiment, an objective having a focal length of 240 mm and a relative power of 1:16 was employed. It was found that the above theory describes the experimentally obtained results to a high degree of accuracy.

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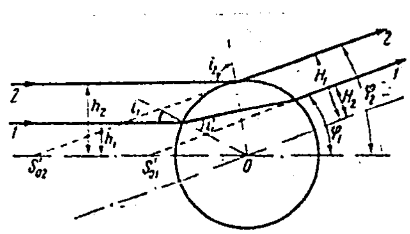
Formation of the Image in the Photography of Bubble-chamber Tracks



There are 2 figures and 1 Soviet reference.

ASSOCIATIONS: Fizicheskiy institut AN SSSR (Physics Institute of the AS USSR) Moskovskiy fiziko-tekhnicheskiy institut (Moscow Physico-technical Institute)

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S/120/60/000/006/032/045
E032/E314

Formation of the Image in the Photography of Bubble-chamber Tracks

SUBMITTED: September 29, 1959

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69090

S/120/60/000/01/034/051
E032/E314

21.5200

AUTHORS: Aleksandrov, Yu.A., Gorbunkov, V.M., Delone, N.B. and Likhachev, V.M.

TITLE: On the Formation of Image in Bubble-chamber Track Photography

PERIODICAL: Pribory i tekhnika eksperimenta, 1960, Nr 1, pp 113 - 114 (USSR)

ABSTRACT: The bubbles which form the particle tracks in a bubble chamber are light scattering irregularities. They may be looked upon as spherical lenses having a refractive index which is different from that of the surrounding medium. The optical properties of such irregularities are determined by their relative refractive index and radius of curvature (Ref 1). In a bubble chamber, the refractive index of the liquid is greater than that of the bubble and, therefore, the latter behaves as a negative lens. The incident light is therefore refracted in the bubble and produces a virtual image of the source of light near the image of this "lens". Rays refracted by the lens and entering the objective of the photographic camera produce an image, not of the

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On the Formation of Image in Bubble-chamber Track Photography

bubble, but the virtual source which lies near the focus of the bubble. It is therefore of interest to consider the effect of the difference in the position of the bubbles and the corresponding images of the source of light. For paraxial rays incident from infinity the distance from the centre of the spherical lens of radius R to the image is given by:

$$f' = \frac{1}{2} Rn_2/\Delta n$$

where Δn is the difference between the refractive indices of the liquid and the bubble. Each point of the source of light is imaged near the focus of the spherical lens, and the entire source is imaged with a magnification given by $\beta \cong f'/L$ where L is the distance from the source of light to the bubble. Clearly, in the case of bubble chambers and particularly in the case of liquid-hydrogen bubble chambers in which Δn is small, the spatial separation of the bubbles and the images of the light sources will be very small. It has

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On the Formation of Image in Bubble-chamber Track Photography

been found with the aid of a model that aberration and diffraction effects are negligible. A large-scale photograph was taken of bubbles in a propane chamber using the apparatus shown in Figure 1. The illuminating system consists of a source of light S , an opaque screen A and a diffuse reflector B . Figure 2 shows photographs of electron tracks in the propane bubble chamber. The electrons were due to Co^{60} sources. In Figure 2, photograph (a) was obtained with a single source (a small hole in a screen); (б) with two holes; (B) with three holes; (г) and (д) with a ring source. From a knowledge of the geometry of the experiment it was possible to estimate the diameters of the bubbles. They were found to be between 0.1 and 0.4 mm, depending on illumination conditions. It is concluded that the recorded bubbles are in fact images of the source of light. The spatial displacement of the image of the source relative to the centre of the bubble is not small. Thus, in the case of liquid hydrogen the quantity f' is

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E032/E314

On the Formation of Image in Bubble-chamber Track Photography

approximately equal to 6R . Acknowledgment is made to G.G. Slyusarev for valuable discussions.
There are 2 figures and 1 Soviet reference.

ASSOCIATION: Fizicheskiy institut AN SSSR (Physical Institute of the Ac.Sc., USSR)

SUBMITTED: November 20, 1958

Card 4/4

BEILE, T.S.; GORBUNKOV, V.M.; ROZENBERG, L.D.

Calculating the amplification factor of a sound wave falling obliquely on a parabolic mirror. Akust.zhur. 8 no.3:273-280 '62. (MIRA 15:11)

1. Akusticheskiy institut AN SSSR, Moskva. (Sound waves)

S/051/63/014/003/017/019
E032/E514

AUTHORS: Belonogov, A.V. and Gorbunkov, V.M.

TITLE: Measurement of the refractive index of liquid hydrogen

PERIODICAL: Optika i spektroskopiya, v.14, no.3, 1963, 438-440

TEXT: It is noted that a knowledge of the refractive index of liquid hydrogen is of importance in the analysis of bubble-chamber photographs. The authors describe the principle of a device which may be used to determine the refractive index of liquid parahydrogen and normal hydrogen (25% para- + 75% ortho-hydrogen) in the equilibrium state at pressures of 1-9 atm to an accuracy of better than $\pm 2 \cdot 10^{-4}$. It can also be used to determine the difference in the refractive indexes of these two modifications in a given container to better than $\pm 10^{-4}$. The device is based on the fact that a plane-parallel plate (see figure) will displace the point of convergence (A) of a homocentric beam by an amount Δ which is proportional to the thickness of the plate and its refractive index. The object is a narrow slit 1 which is illuminated by a monochromatic source 2. It is imaged by a

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lens 3 in such a way that the converging beams pass through an evacuated vessel with plane-parallel windows and then again through the same vessel filled with liquid hydrogen. In order to ensure the necessary accuracy of determining the displacement Δ, two pairs of slits 4 and 4' are introduced symmetrically with respect to the lens 3 and define narrow beams. The latter are diffracted in such a way that two pairs of fringes are formed in the plane of the image of the slit. A small optical wedge 5 is used to displace one of the systems relative to the other. The image is observed through the microscope 6 with the container evacuated and filled with hydrogen. The refractive index n is then given by

$$n = \cos u \sqrt{\frac{t^2}{(t - \Delta)^2} + \mathrm{tg}^2\, u} \qquad (1)$$

where t is the thickness of the hydrogen layer, 2u is the angle between the axes of the diffracted beams in air and Δ is the measured displacement of the plane of the image. The device has been used to determine the refractive index as a function of density and temperature at λ = 5460 Å. The density dependence is linear, while the temperature dependence is linear up to about 26°K and thereafter falls off more rapidly as the temperature increases. There are 4 figures.

SUBMITTED: September 28, 1962

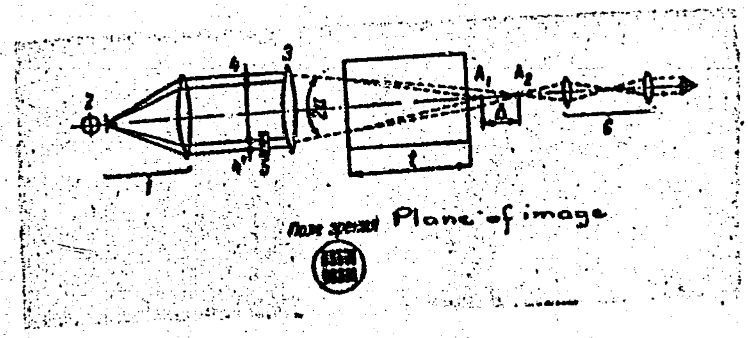

Fig.1

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ALEKSANDROV, Yu.A.; VORONOV, G.S.; GORBUNKOV, V.M.; DELONE, N.B.; NECHAYEV, Yu.I.; MATVEYEVA, A.V., red.; POPOVA, S.M., tekhn. red.

[Bubble chambers] Puzyr'kovye kamery. [By] IU.A.Aleksandrov i dr. Moskva, Gosatomizdat, 1963. 339 p. (MIRA 17:1)

L 24507-65 EWT(m) IJP(c)/SSD/BSD/AFMD(c)/AEDC(a)/SSD(a)/AFWL/ASD(p)-3
AM4020390 BOOK EXPLOITATION ASD(a)-5

Aleksandrov, Yu. A.; Voronov, G. S.; Gorbunkov, V. M.; Delone, N. B.; Nechayev, Yu. I.

Bubble chambers (Puzyr'kovyye kamery) Moscow, Gosatomizdat, 1963. 339 p. illus., biblio. Errata slip inserted. 3600 copies printed. Under the editorship of: Delone, N. B.; Editor: Matveyeva, A. V.; Technical editor: Popova, S. M. Proofreader: Smirnov, M. A.

TOPIC TAGS: Bubble chamber, charged particle, track formation, track observation, photofilm scattering, hydrogen refraction, superheated liquid, vapor bubbles, hydrogen chamber

PURPOSE AND COVERAGE: The book represents the first attempt at a systematic exposition of the principles of the operation and the design of bubble chambers and of their possibilities for the observation of particles. Special attention is paid to the physics of the formation and the observation of tracks in the bubble chamber, to generalization of separate data concerning the properties of the working medium, and to chamber design and future trends. V. I. Veksler directed the

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authors' attention to the need for this compilation. The authors utilized the work of specialists at the Ob"yedinennyy Institut Yadernykh Issledovaniy, the Institut Teoreticheskoy i Eksperimental'noy Fiziki, the Fizicheskiy Institut Akademii Nauk SSSR, and the Moskovskiy Inzhenerno-Fizicheskiy Institut. The authors were aided directly by L. Bernshteyn (computing the scattering of [illegible] films), V. Morozov (checking the computations of the geometric theory of indicatrices), E. Sviridenkov and A. Suchkov (obtaining data concerning [illegible] lines of hydrogen [illegible] (programming and performing [illegible] [illegible] the illustrations).

TABLE OF CONTENTS:

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L 24507-65
AM4020390

SUB CODE: NP SUBMITTED: 24Sep63 NR REF SOV: [illegible]

OTHER: 255

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L 12922-66 EWT(m) IJP(c)

ACC NR: AP6000952 SOURCE CODE: UR/0286/65/000/022/0039/0039

44,55 44,55 44,55 44,55

AUTHORS: Galanin, M. D.; Gorbunkov, V. M.; Delone, N. B.; Korobkin, V. V.; Leontovich, A. M.; Saitov, I. S.

44,55 44,55

71

B

ORG: none

19,55,44

TITLE: A method for illuminating particle tracks in chambers for the visual observation of tracks. Class 21, No. 176332

SOURCE: Byulleten' izobreteniy i tovarnykh znakov, no. 22, 1965, 39

TOPIC TAGS: laser, particle track, coherent light

ABSTRACT: This Author Certificate presents a method for illuminating the particle tracks in chambers for visual observation of tracks by pulsed light radiation. To increase the accuracy of the physical experiment, an optical quantum generator (laser) with confocal resonators is used for illuminating.

SUB CODE: 14/ SUBM DATE: 18Jun64

Card 1/1 HW UDC: 621.375.8:539.1.073.8

L 64113-65 EWP(e)/EWT(m)/EWP(i) WH

ACCESSION NR: AP5021096 UR/0056/65/049/00

AUTHOR: Barkhudarova, T. M.; Voronov, G. S.; Gorbunkov, V. M.; Delone, N. B.

TITLE: Spatial distribution of the electrical field set up by a focused ruby laser beam

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 49, no. 2, 1965, 386-388

TOPIC TAGS: ruby laser, laser field, field distribution, spatial distribution, focused laser, laser output

ABSTRACT: The spatial distribution of the electric field set up by a Q-switched pulsed ruby laser was investigated. The laser consisted of standard ruby crystals 120 mm long and 10 mm in diameter. A spiral IFK-15000 lamp and a ... used for pumping and Q-switching, respectively. The laser ... from several Mw to several tens of Mw. The beam was focused by lenses ... and 120 mm which were corrected for spherical abberation for ...

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L 64113-65

ACCESSION NR: AP5021096

the diffraction-distributed beam from individual ... the individual diffract...

...

distribution of the ... between the lens and the laser ...
f and increasing ... can be attained, the process is limited by the ...
trical fields can be attained, the process is limited by the ...
the focusing lens. Further improvement of the field intensity can be achieved by
reducing the number of resonator modes. Orig. art. has: 2 figures.

ASSOCIATION: ...
Institute ...

SUBMITTED: 24Feb65 ENCL: 00

NO REF SOV: 002 OTHER: 001 ATD PRESS: 4074

Card 2/2

L 1618-66 EWA(k)/FBD/EWT(1)/EWP(e)/EWT(m)/EEC(k)-2/EWP(i)/T/EWP(k)/EWA(m)-2/EWA(h)
SCTB/IJP(c) WG/WH
ACCESSION NR: AP5023361

UR/0020/65/164/001/0075/0077
621.375.8:539.1.073.3

AUTHOR: Gorbunkov, V. M.; Korobkin, V. V.; Leontovich, A. M.

TITLE: Illumination of a bubble chamber by means of a ruby laser

SOURCE: AN SSSR. Doklady, v. 164, no. 1, 1965, 75-77 and top third of insert facing page 76

TOPIC TAGS: laser, ruby laser, laser illuminator, bubble chamber

ABSTRACT: A concentric-resonator ruby laser (λ = 6943 Å) was used to illuminate particle tracks in a bubble chamber. The experimental setup is shown in Fig. 1 of the Enclosure. The resonator consisted of dielectric-coated, concave spherical mirrors with a transmission of ∼1% and 50-cm radii placed at a 100-cm distance. The ruby rod, 75 mm long and 9 mm in diameter, was pumped by 0.1-j pulses approximately 0.6 msec in duration from a 4-kj IFK-1500 flash lamp. The laser beam was uniformly distributed with an ∼2° angular divergence which was magnified by an f = 50 mm lens to 20°. The experiments were carried out on a bubble chamber model consisting of a plane-parallel plate filled with air bubbles which corresponded to a 25 cm hydrogen bubble chamber described elsewhere (T. D. Blokhintseva, et al, Pribory i

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L 1618-66
ACCESSION NR: AP5023361

4

tekhnika eksperimenta, no. 5, 51, 1962). The test object T was placed 50 cm from the lens 0 and was illuminated by a concave spherical mirror M_0 (radius of curvature, 65 cm; diameter, 23 cm) placed 70 cm from 0. The laser-illuminated bubble tracks were photographed from a distance of ~50 cm with an f = 53 mm camera on a film with a 70 line/mm resolving power. The excess light was filtered by a combination of an interference filter at λ = 694 mμ with a 30% transmission and a neutral filter with an 11% transmission. The test object was photographed 5 times at different camera angles. The results indicate that the use of a laser illumination system without a filter makes it possible to record bubbles up to 0.06 mm in diameter in hydrogen. Small bubbles in larger chambers (e.g., Wilson's chamber) can be recorded at higher generation energies. Recording at reduced energies can also be effective in cases where low-sensitivity, high-resolution film is used for better contrast and accuracy. Orig. art. has: 1 formula and 2 figures. [YK]

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute, Academy of Sciences SSSR); Moskovskiy fiziko-tekhnicheskiy institut (Moscow Physicotechnical Institute) 44

SUBMITTED: 15Jan65 44 ENCL: 01 SUB CODE: EC, NP

NO REF SOV: 005 OTHER: 003 ATD PRESS: 4095

Card 2/3

L 1618-66

ACCESSION NR: AP5023361 ENCLOSURE: 01

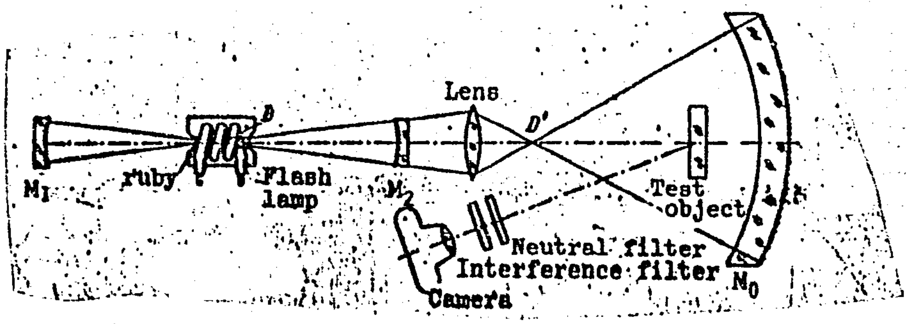

Fig. 1. Diagram of systems for illumination and photography of bubbles

Card 3/3

GORBUNKOVA, L. A.

GORBUNKOVA, L. A. "A case of elephantiasis of the vulva", Trudy Smol. gos. med. in-ta, Vol. II, 1948, p. 327-29.

SO: U-4393, 19 August 53, (Letopis 'Zhurnal 'nykh Statey', No. 22, 1949).

GORBUNKOVA, Z. A.

GORBUNKOVA, Z. A. "On the problem of the serous inflammation of the liver," Trudy Smol. gos. med. in-ta, Vol. II, 1948, p. 196-99.

SO: U-4393, 19 August 53, (Letopis 'Zhurnal 'nykh Statey', No. 22, 1949)

GORBUNKOVA, Z. A.

GORBUNKOVA, Z. A. and KROVKO, L. G. "Acase of acute pancreatitis of malarial origin," Trudy Smol. gos. med. in-ta, Vol. II, 1948, p. 337-39.

SO: U-4393, 19 August 53, (Letopis 'Zhurnal 'nykh Statey', No. 22, 1949).

GORBUNKOVA, Z.A.

Soporific effect of oxygen therapy. Sov.med.18 no.1:13-15
Ja '54. (MLRA 7:1)

1. Iz propedevticheskoy i fakul'tetskoy terapevticheskoy kliniki Smolenskogo meditsinskogo instituta i kafedry patologicheskoy fiziologii TSentral'nogo instituta usovershenstvovaniya vrachey.
(Oxygen--Therapeutic use)

GORBUNKOVA, Z.A., kand.med.nauk

Method of oxyhemometric investigations during oxygen therapy in oxygen tents. Terap. arkh. 29 no.8:24-31 '58. (MIRA 11:4)

1. Iz kliniki propedevtiki vnutrennikh bolezney (zav.-dotsent Z.A. Gorbunkova) Smolenskogo meditsinskogo instituta.

(OXYGEN, in blood,

determ. in patients in oxygen tents & during oxygen ther. (Rus)

GORBUNKOVA, Z.A., dotsent

Method for preparing various oxygen concentrations for use in oxygen tent therapy. Terap. arkh. 30 no.11:10-15 N '58 (MIRA 12:7)

1. Iz kafedry propedevtiki vnutrennikh bolezney Smolenskogo meditsinskogo instituta.
(OXYGEN--THERAPEUTIC USE)

GCRBUNKOVA, Z.A.

Oxyhemometry as a method for evaluating the effectiveness of oxygen therapy in patients with chronic cardiopulmonary insufficiency. Terap. arkh. 32 no. 4:63-72 S '60. (MIRA 14:1)
(PULMONARY HEART DISEASE) (OXYGEN THERAPY)
(BLOOD—OXYGEN CONTENT)

GORBUNKOVA, Z.A., dotsent

Curves of oxygen saturation of the arterial blood and its diagnostic significance in the evaluation of the effectiveness of oxygen therapy in patients with arterial hypoxemia. Terap. arkh. 33 no.4:31-42 '61. (MIRA 14:5)

1. Iz kafedry propedevticheskoy terapii Smolenskogo meditsinskogo instituta.
(ANOXEMIA) (OXYGEN THERAPY)

GORBUNOV, A.

Outlining an overall plan of sanitary measures. Okh.truda i sots. strakh. no.1:70-71 Ja '60. (MIRA 13:5)
(MEDICINE, INDUSTRIAL)

GORBUNOV, A.

Be thrifty in dispensing vacancies for medical treatment. Okhr. truda i sots. strakh. 3 no.7:36-37 Jl '60. (MIRA 13:8)
(Ivanovo Province--Labor and laboring classes--Medical care)

MALYKHIN, V. (Leningrad); GORBUNOV, A. (Leningrad)

Fruit of a routine approach. Okhr.truda i sots.strakh. 5 no.12:27-28 D '62. (MIRA 16:2)

1. Spetsial'nyye korrespondenty zhurnala "Okhrana truda i sotsial'noye strakhovaniye".
(Leningrad—Medicine, Industrial)

GORBUNOV, A.

Is this the way to serve patients? Okhr. truda i sots. strakh. 4 no.3:25-26 Mr '61. (MIRA 14:3)

1. Spetsial'nyy korrespondent zhurnala "Okhrana truda i sotsial'noye strakhovaniye" g. Pyatigorsk.
(Patigorsk—Health resorts, watering places, etc.)

GORBUNOV, A.

Along the path of continuous growth. Okhr. truda i sots. strakh. 4 no.9:3-5 S '61. (MIRA 14:10)

(Insurance, Social)

GORBUNOV, A.

Toward new milestones. Mest. prom. i khud. promys. 2 no.9:5 S '61.
(MIRA 14:11)

1. Direktor mozhginskoy fabriki "Krasnaya zvezda", g. Mozhga, Udmurtskoy ASSR.
(Udmurt A.S.S.R.—Woodworking industries)

LUNEVA, A., domokhozyayka; PLOTNIKOVA, A., lifter; YEGOROVA, N.; GANTSEV, M., slesar'-montazhnik; GORBUNOV, A.

In order to keep in a good mood. Zhil.-kom.khoz. 12 no.6:30-31 Je '62. (MIRA 15:12)

1. Zaveduyushchaya priyemnym punktom "Akademgorodka" (for Yegorova). 2. Vostoktekhmontazh (for Gantsev). 3. Direktor bani i prachechnoy No.3 g. Novosibirsk (for Gorbunov).
(Novosibirsk—Baths, Public)
(Novosibirsk—Laundries, Public)

SALTYKOV, V., podpolkovnik; GORBUNOV, A., podpolkovnik

So firing in the mountains may be accurate. Voen.vest. 42 no.9:104-108 S '62. (MIRA 15:8)
(Artillery, Field and mountain) (Mountain warfare)

YEGORSHIN, N.A.; SHERSHEN', F.M.; SMIRNOV, A.N.; GORBUNOV, A.D.; YEGOROV, V.P.; VASIL'YEV, A.V.; KOLOMEYTSEV, K.N.; KOLEGOV, V.A.; KASATKINA, N.P., red.

[Mechanisms for lumbering camps; from work practices of the construction office of the Chusovskoye Logging Camp] Mekhanizmy dlia lesozagotovok; iz opyta raboty konstruktorskogo biuro Chusovskogo lespromkhoza. Moskva, TSentr.nauchno-issl.in-t informatsii i tekhniko-ekon.issledovanii po lesnoi, tselliulozno-bumazhnoi, derevoobrabatyvaiushchei promyshl. i lesnomu khoz. 1963. 21 p. (MIRA 17:4)

GORBUNOV, A. D.

Mathematical Reviews
Vol. 14 No. 8
Sept. 1953
Analysis

Gorbunov, A. D. On a method for obtaining estimates of the solution of a system of ordinary linear homogeneous differential equations. Vestnik Moskov. Univ. Ser. Fiz.-Mat. Estest. Nauk 1950, no. 10, 19–26 (1950). (Russian)

Consider the system of linear homogeneous differential equations $dx/dt = E(t)x$ in which t is time, x is a real n-vector, and $E(t)$ is a square matrix of nth order, the elements of which are real, single-valued, and continuous functions of t in the interval $0<t<\infty$. By the method of successive approximations one may obtain a bound for the components of the solution in any interval $0<t<\tau$. But this bound goes to infinity as τ goes to infinity and therefore is not suitable for problems which are stable in the sense of Lyapunov. The object of this paper is the derivation of a formula which provides a bound more closely approximating the actual bounds for the case where x oscillates without increasing indefinitely. The author succeeds in finding a formula for such a bound provided it is possible to select a positive definite quadratic form in the n components of x which satisfies certain conditions.

GORBUNOV, A. D.

Gorbunov, A. D. (Mathematics) Conditions of the monotonous stability of a system of common linear uniform differential equations. P. 15

Chair of Differential equations
Jan. 11, 1950

SO: Herald of the Moscow University (Vestnik), Series on Physical, Mathematical and Natural Sciences, No. 2, Vol. 6, No. 3, 1951

GORBUNOV, A. D.

A. D. Gorbunov. Certain solution properties of common linear systems of uniform differential equations. P. 3

Chair of Differential Equations, March 5, 1951

SO: Herald of the Moscow University, Series of Physics-Mathematics and Natural Sciences, No. 4; No. 6, 1951

GORBUNOV, A. D.

GORBUNOV, A. D. USSR/Mathematics - Differential Equations Sep 53

"Conditions for Asymptotic Stability of the Null Solution of a System of Ordinary Linear Homogeneous Differential Equations," A. D. Gorbunov, Chair of Diff Eq

Vest Mos Univ, Ser Fizikomat i Yest Nauk, No 6, pp 49-55

The article considers conditions under which the Lyapunov sufficiency conditions for asymptotic stability can be transformed into necessary and sufficient conditions for asymptotic stability of the null solution. The following theorem is proved:

275T85

In order that the null solution of a system of the type $\frac{dx}{dt} = L(t)x$ possess Lyapunov asymptotic stability, it is necessary and sufficient that there exist a positive definite quadratic form $G(t;x)$ with continuously differentiable coefs, such that the conjugate quadratic form $g(t;x)$ relative to the system $\frac{dx}{dt} = L(t)x$ is essentially negative in the interval $-\infty < t < +\infty$ for which the integral $\int_{t_0}^{\infty} N_G(t)dt$ converges. Presented 18 Mar 53.

GORBUNOV, A.D.

Conditions of asymptotic stability in the zero method of solving simple li
homogeneous differential equations. Vest.Mosk.un.8 no.9:49-55 S '53.
(MLRA 6:11)

1. Kafedra differentsial'nykh uravneniy. (Differential equations, Lin

GORBUNOV, A. D.

USSR/Mathematics - Differential equations FD-668

Card 1/1 : Pub. 129 - 3/25

Author : Gorbunov, A. D.

Title : Evaluations of the coordinates of the solutions to systems of ordinary linear differential equations

Periodical : Vest. Mosk. un., Ser. fizikomat. i yest. nauk, Vol. 9, No. 5, 27-32, May 1954

Abstract : Continues his earlier exposition (ibid. No. 12, 1952) of certain properties possessed by the solutions to a system of ordinary linear differential equations of the type $dy/dt = L(t)\, y + f(t)$, where t is the independent real variable time, y is a matrix column, L(t) is a square matrix of the n-th order, and f(t) is a matrix column.

Institution : Chair of Differential Equations

Submitted : January 28, 1954

GOR[redacted]

Certain problems in the qualitative theory of ordinary linear uniform differential equations with variable coefficients. Uch.zap.Mosk.un. 165:39-78 '54. (MLRA 8:2)
(Differential equations, Linear)

Gorbunov, A. D. Estimates of characteristic exponents of solutions of a system of ordinary linear homogeneous differential equations. Vestnik Moskov. Univ. 11 (1956), no. 2, 7–13. (Russian)

Given a homogeneous linear system (*) $x'=A(t)x$, $x=(x_1, \cdots, x_n)$, whose coefficients are real continuous bounded functions of t in $[0, +\infty)$, the author considers, in line with his previous paper [same Vestnik 1950, no. 10, 19–26; MR 14, 751], a quadratic form

$$G(t, x)=\sum A_{ik}(t)x_i x_k \ (A_{ik}=A_{ki}),$$

which is positive definite for $t\geqq 0$, and whose coefficients are continuous bounded real functions of t in $[0, +\infty)$. If $g(t, x)$ denotes the usual derivative of G written in terms of the system (*), and $n_G(\tau)$, $N_G(\tau)$ denote the minimum and the maximum of $g(\tau, x)$ for all real x with $G(\tau, x)=1$, then the author proves the following estimates of the Lyapunov type numbers $\pi[x(t)]$ of the nontrivial solutions $x(t)$ of (*):

(a) $$2\pi[x(t)]\geqq \limsup t^{-1}\int_0^t n(\tau)d\tau,$$

(b) $$2\pi[x(t)]\leqq \pi[\omega]+\limsup t^{-1}\int_0^t N_G(\tau)d\tau,$$

where lim sup are taken as $t\to+\infty$, and $\omega(t)$ is the vector of the n principal minors of $A(t)=[A_{ik}]$ divided by the determinant of $A(t)$. Use is made of results of the quoted paper by the same author. L. Cesari (Lafayette, Ind.).

GORBUNOV, A.D.; BUDAK, B.M.

Difference method for solving a nonlinear Goursat problem.
Vest. Mosk.un.Ser. mat. mekh. astron. fiz. khim. 12 no.4:3-8
'57. (MIRA 11:5)

(Difference equations)

AUTHOR: BUDAK, B.M., GORBUNOV, A.D. 20-4-3/52

TITLE: On the Difference Method for the Solution of the Nonlinear Goursat Problem (O raznostnom metode resheniya nelineynoy zadachi Gursa)

PERIODICAL: Doklady Akademii Nauk SSSR, 1957, Vol 117, Nr 4, pp 559-562 (USSR)

ABSTRACT: The authors use the Difference method for the solution of the Goursat problem

$$u_{xy} = f(x,y,u,u_x,u_y),$$

$$u(x,0) = \varphi(x); \quad 0 \le x \le l_x; \quad u(0,y) = \psi(y), \quad 0 \le y \le l_y; \quad \varphi(0) = \psi(0)$$

for an arbitrary right side $f(x,y,u,u_x,u_y)$ which only in the region of definition $0 \le x \le l_x$, $0 \le y \le l_y$, $|u-u^0| \le l_n$, $|u_x-u_x^0| \le l_{u_x}$, $|u_y-u_y^0| \le l_{u_y}$ is assumed to be continuous in all arguments and in u, u_x, u_y it is assumed to be sufficiently smooth. The functions $\varphi(x)$ and $\psi(y)$ are continuously differentiable With the aid of a general criterion of convergence it is stated that if f satisfies the Lipschitz condition in u_x and u_y, then

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the problem has a continuously differentiable solution. If the Lipschitz condition is satisfied also in u, then the solution is unique. For the case that f, $\varphi'(x)$ and $\psi'(y)$ satisfy the Lipschitz condition in all arguments, the error is estimated by the steps in x and y and by the maximal values of the functions and their derivatives and by the Lipschitz constant. Finally the results are extended to a system of equations in the m-dimensional space.
3 Soviet and 3 foreign references are quoted.

ASSOCIATION: Moscow State University im.M.V.Lomonosov (Moskovskiy gosudarstvennyy universitet im. M.V.Lomonosova)
PRESENTED: By S.L.Sobolev, Academician, 31 May 1957
SUBMITTED: 31 May 1957
AVAILABLE: Library of Congress
Card 2/2

AUTHORS: Budak, B.M., and Gorbunov, A.D. SOV/55-58-1-2/33

TITLE: On the Convergence of Some Difference Methods for the Equations $y' = f(x,y)$ and $y'(x) = f[x,y(x),y(x-\tau(x))]$ (O skhodimosti nekotorykh konechno-raznostnykh protsessov dlya uravneniy $y' = f(x,y)$ i $y'(x) = f[x,y(x), y(x-\tau(x))]$)

PERIODICAL: Vestnik Moskovskogo universiteta, Seriya fiziko-matematicheskikh i yestestvennykh nauk, 1958, Nr 1, pp 23-32 (USSR)

ABSTRACT: Given the problem

(1) $$y' = f(x,y),$$

(2) $$y(x_0) = y_0 \qquad (x_0,y_0) \in G.$$

The approximate values y_i of y are obtained from the difference equation

(3) $$\sum_{i=0}^{m} \alpha_i y_{k-i} = h \sum_{i=0}^{n} \beta_i f_{k+1-i}, \quad f_i = f(x_i,y_i), \quad x_i = x_0 + ih,$$

where the initial conditions are prescribed by

(4) $$y_i = g(x_i),$$

where $g(x)$ is a continuously differentiable function changing with h. Furthermore the difference equation

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(5) $$\sum_{i=0}^{m-1}(\alpha_0+\dots+\alpha_i)\,\varphi(x_{k-i}) = h\,\psi(x_k)$$

is considered, where $\psi(x_k)$ is defined and finite in the points x_k, $\|\psi\| = \max|\psi(x_k)|$. Let the solution of (5) be written in the form $\varphi_k = hB_h\psi_k$, where B_h is a linear bounded operator,

$$\|B_h\| = \max_{0\le k\le N_h}\sum_{i=0}^{h-1}|\gamma_{ki}|,\quad N_h = \left[\frac{x-x_0}{h}\right],$$ γ_{k_i} is determined by a fundamental solution of the homogeneous equation (5).

Theorem: Let the coefficients of (3) satisfy the conditions

$$\sum_{i=0}^{m}\alpha_i = 0,\quad \sum_{i=0}^{m-1}(\alpha_0+\dots+\alpha_i) = \sum_{i=0}^{n}\beta_i \neq 0.$$

For the uniform convergence of the difference process defined by (3) it is necassary and sufficient that $\|B_h\|$ is uniformly bounded in h, that the absolute values of the simple roots of

On the Convergence of Some Difference Methods for the Equations $y' = f(x,y)$ and $y'(x) = f[x, y(x), y(x-\tau(x))]$ SOV/55-58-1-2/33

$$\sum_{i=0}^{m-1} (\alpha_0 + \dots + \alpha_i)\lambda^{m-1-i} = 0$$

are smaller or equal to one, and that the absolute values of the multiple roots <1.
The exactness of the difference method is estimated.
There are 10 references, 7 of which are Soviet, 1 German, 1 Swedi[sh] and 1 American.

ASSOCIATION: Kafedra matematiki dlya fizicheskogo f-ta i kafedra vychislitel'n[oy] matematiki mekhaniko-matematicheskogo f-ta (Chair of Mathematics of the Dept. of Physics and Chair of Numerical Mathematics of the Dept. of Engineering Mathematics)

SUBMITTED: June 14, 1957

Card 3/3

A.D. Gorbunov

16(1)

AUTHORS: Skoryy, I.A., University Lecturer, and Kopytov, V.D., Scientific Assistant SOV/55-58-2-33/35

TITLE: Lomonosov - Lectures 1957 at the Mechanical-Mathematical Faculty of Moscow State University (Lomonosovskiye chteniya 1957 goda na mekhaniko-matematicheskom fakul'tete MGU)

PERIODICAL: Vestnik Moskovskogo Universiteta. Seriya matematiki, mekhaniki, astronomii, fiziki, khimii, 1958, Nr 2, pp 241-246 (USSR)

ABSTRACT: The Lomonosov lectures 1957 took place from October 17 - October 31, 1957 and were dedicated the 40-th anniversary of the October revolution.

16. A.D. Gorbunov, Lecturer and B.M. Budak, Lecturer : Difference Methods for the Solution of Hyperbolic Equations.
17. N.S. Bakhvalov : Number of Calculation Operations for the Solution of Elliptic Equations.
18. V.I. Lebedev, Aspirant : Difference Method for the Solution of the Sobolev-System.
19. Professor Ye.B. Dynkin : Markov Processes and Semigroups.
20. A.G. Kostyuchenko, Candidate of Physical-Mathematical Sciences : Decomposition of Differential Operators With Respect to Generalized Eigenfunctions.
21. F.A. Berezin, Candidate of Physical-Mathematical Sciences: Foundations of the Theory of Spherical Harmonics on Manifolds.
22. V.M. Borok, Aspirant : General Properties of Partial Evolution Systems.
23. V.A. Uspenskiy, Candidate of Physical-Mathematical Sciences : On Constructive Mathematical Analysis.
24. P.L. Ul'yanov, Lecturer : Reversal of Terms in Trigonometric Series.
25. I.G. Petrovskiy, Academician and Ye.M. Landis, Senior Scientific Assistant : On the Number of Boundary Cycles of a Differential Equation of First Order With a Rational Right Side.

The contents of all the lectures have already been published.

Card 5/5

(12)

1

16(1) SOV/55-58-3-1/30

AUTHORS: Gorbunov, A.D. and Budak, B.M.

TITLE: The Method of Straight Lines for the Solution of a Non-Linear Boundary Value Problem in a Curvilinearly Bounded Domain (Metod pryamykh dlya resheniya odnoy nelineynoy krayevoy zadachi v oblasti s krivolineynoy gradnitsey)

PERIODICAL: Vestnik Moskovskogo universiteta, Seriya matematiki, mekhaniki, astronomii, fiziki, khimii, 1958, Nr 3 pp 3-12 (USSR)

ABSTRACT: The method of straight lines already applied for several times by the authors [Ref 1-3] is used in order to prove the existence, uniqueness und continuous dependence on the boundary conditions of the solution of the following boundary value problem : A continuously differentiable solution of the equation $u_{xy} = f(x,y,u,u_x,u_y)$ is to be found which satisfies the boundary conditions $u(x,g(x)) = \varphi(x)$, $0 \leqslant x \leqslant l_x$; $u(0,y) = \psi(y)$, $0 \leqslant y \leqslant l_y$. Here f is defined and continuous in $\bar{g}$: $0 \leqslant x \leqslant l_x$, $g(x) \leqslant y \leqslant l_y$, $|u| \leqslant l_u$, $|u_x| \leqslant l_{u_x}$, $|u_y| \leqslant l_{u_y}$ and satisfies the Lipschitz conditions with respect to u_x and u_y ; $g'(x) \geqslant 0$ for

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SOV/55-58-3-1/30

The Method of Straight Lines for the Solution of a Non-Linear Boundary Value Problem in a Curvilinearly Bounded Domain

$0 \leqslant x \leqslant l_x$, $g(0) = 0$, $g'(x)$ - continuous, $\varphi'(x)$, $\psi'(y)$ - continuous; the upper bounds of the absolute values of φ, φ' etc. furthermore satisfy certain inequalities.

There are 3 Soviet references.

ASSOCIATION: Kafedra vychislitel'noy matematiki mekhaniko-matematicheskogo f-ta i kafedra matematiki fizicheskogo f-ta (Chair of Computing Mathematics of the Mathematical-Mechanical Department and Chair of Mathematics of the Physical Department)

SUBMITTED: July 17, 1957

Card 2/2

16(1) SOV/55-58-5-2/34

AUTHORS: Budak, B.M., and Gorbunov, A.D.

TITLE: On the Difference Method for the Solution of the Cauchy Problem for the Equation $y' = f(x,y)$ and for the System of Equations $x_i' = X_i(t,x_1,\ldots,x_n)$, $i = 1,\ldots,n$, With Discontinuous Right Sides (O raznostnom metode resheniya zadachi Koshi dlya uravneniya $y' = f(x,y)$ i dlya sistemy uravneniy $x_i' = X_i(t,x_1,\ldots,x_n)$, $i = 1,\ldots,n$ s razryvnymi pravymi chastyami)

PERIODICAL: Vestnik Moskovskogo universiteta, Seriya matematiki, mekhaniki, astronomii, fiziki, khimii, 1958,Nr 5,pp 7 - 12 (USSR)

ABSTRACT: Let the Cauchy problem $y' = f(x,y)$, $y(x_0) = y_0$ be set up, where $f(x,y)$ is defined in $|x-x_0| \leqslant A$, $|y-y_0| \leqslant B$ and along certain singular curves suffers jumps in this rectangle, while it is uniformly continuous within each partial domain and satisfies the Lipschitz condition in y. The Eulerian polygonal curves are constructed and their convergence to the sought solution, the uniqueness of the solution and the continuous dependence of the solution on initial values and parameters

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On the Difference Method for the Solution of the Cauchy Problem for the Equation $y' = f(x,y)$ and for the System of Equations $x_i' = X_i\ (t,x_1,\ldots,x_n)$, $i = 1,\ldots,n$, With Discontinuous Right Sides

SOV/55-58-5-2/34

is proved. The same results are obtained for the system of equations mentioned in the title.
There is 1 Soviet reference.

ASSOCIATION: Kafedra matematiki fizicheskogo fakul'teta i vychislitel'noy matematiki mekhaniko-matematicheskogo fakul'teta (Chair of Mathematics of the Physical Department and Chair of Computing Mathematics of the Mechanical-Matnematical Department)

SUBMITTED: June 23, 1958

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4

SOV/155-58-6-5/36

~~16(1)~~ 16.3400 16.3900 16.6500

AUTHORS: Gorbunov, A.D., Budak, B.M.

TITLE: On the Difference Method for the Solution of the Cauchy Problem for the System of Equations $x_i' = X_i(t,x_1,\ldots,x_n)$, $(i = 1,\ldots,n)$ With Discontinuous Right Sides

PERIODICAL: Nauchnyye doklady vysshey shkoly. Fiziko-matematicheskiye nauki 1958, Nr 6, pp 25-29 (USSR)

ABSTRACT: The authors consider the Cauchy problem

(1) $x_i' = X_i(t,x_1,\ldots,x_n)$ $i = 1,\ldots,n$

(2) $x_i(t_o) = x_i^o$ $i = 1,\ldots,n$

where the X_i can be discontinuous. They investigate existence- and uniqueness theorems and the continuous dependence on the initial conditions. The existence theorem is proved with the aid of the Eulerian method of differences which is applied as a homogeneous difference scheme ignoring the position of the discontinuities. The velocity of convergence of the Eulerian

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On the Difference Method for the Solution of the Cauchy Problem for the System of Equations $x_i' = X_i(t,x_1,\dots,x_n)$, $i = 1,\dots,n$ With Discontinuous Right Sides SOV/155-58-6-5/36

polygones is investigated. Altogether three theorems are proved. There are 6 references, 5 of which are Soviet, and 1 Italian.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet imeni M.V. Lomonosova (Moscow State University imeni M.V. Lomonosov)

SUBMITTED: September 17, 1958

Card 2/2

AUTHOR: Budak, B.M. and Gorbunov, A.D. 20-118-5-2/59

TITLE: Straight-Line Method for the Solution of a Non-linear Boundary Value Problem in a Domain With Curvilinear Boundary (Metod pryamykh dlya resheniya odnoy nelineynoy krayevoy zadachi v oblasti s krivolineynoy granitsey)

PERIODICAL: Doklady Akademii Nauk, 1958, Vol 118, Nr 5, pp 858-861 (USSR)

ABSTRACT: The authors consider the equation

(1) $u_{xy} = f(x,y,u,u_x,u_y)$

in the domain

$\bar{G}: \quad 0 \leqslant x \leqslant l_x, \; g(x) \leqslant y \leqslant l_y, \; |u| \leqslant l_u, \; |u_x| \leqslant l_{u_x}, \; |u_y| \leqslant l_{u_y},$

where $g(x) \geqslant 0$ for $0 \leqslant x \leqslant l_x$ and $g'(x) \geqslant 0$ is continuous. It is assumed that f is continuous in $\bar{G}$ and satisfies the Lipschitz condition with respect to u_x and u_y. A continuously differentiable solution is sought which satisfies the boundary conditions

(2) $u(x,g(x)) = \varphi(x) \quad , \; 0 \leqslant x \leqslant l_x \quad ; \; u(0,y) = \psi(y) \quad 0 \leqslant y \leqslant l_y$

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where $\varphi'(x)$ and $\psi'(y)$ are continuous and $M_\varphi + 2M_\psi < l_u$, $M_{\varphi'} + M_{\psi'}M_{g'} < l_{u_x}$, $M_\psi < l_u$, $M_{\psi'} < l_{u_y}$, where $M_\varphi, \ldots$ denotes the upper bound of the modulus of $\varphi, \ldots$

Under these assumptions the existence of at least one solution is proved with the aid of the straight-line method. Under additional conditions the uniqueness and continuous dependence on the boundary conditions is shown and the error of the approximative solution is estimated. There are 3 Soviet references.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet imeni M.V.Lomonosova (Moscow State University imeni M.V. Lomonosov)

PRESENTED: July 17,1957, by A.A. Dorodnitsyn, Academician

SUBMITTED: July 8,1957

GORBUNOV, A.D.; BUDAK, B.M.

Stability of computation processes occurring in solving Cauchy's problem for the equation $dy/dx=f(x,y)$ by means of multiple-point difference methods. Vest. Mosk. un. Ser. mat., mekh., astron., fiz., khim. 14 no.2:15-23 '59 (MIRA 13:3)

1. Kafedry vychislitel'noy matematiki mekhaniko-matematicheskogo fakul'teta i matematiki fizicheskogo fakul'teta Moskovskogo gosuniversiteta.
(Differential equations)

Gorbunov, A.D. and Budak, B.M. (Moscow) 20-119-4-5/59

AUTHOR: Gorbunov, A.D. and Budak, B.M. (Moscow)

TITLE: On the Convergence of Some Different Processes for the Equations $y'=f(x,y)$ and $y'(x)=f(x,y(x),y(x-\tau(x)))$ (O skhodimosti nekotorykh konechnoraznostnykh protsessov dlya uravneniy $y'=f(x,y)$ i $y'(x)=f(x,y(x),y(x-\tau(x)))$)

PERIODICAL: Doklady Akademii Nauk SSSR, Vol 119, Nr 4, pp 644-647 (USSR)

ABSTRACT: Let the equation $y' = f(x,y)$ and the initial condition $y(x_0) = y_0$, $(x_0,y_0) \in G$ be given. Let y_i denote the approximative value of the ordinate $y(x_i)$ of the solution in the points $x_i = x_0 + ih$.

Theorem: If a difference process defined by the equation

$$\sum_{i=0}^{m} \alpha_i y_{k-i} = h \sum_{i=0}^{n} \beta_i f_{k+e-i} \quad , \quad f_j = f(x_j, y_j)$$

converges, then the following conditions are satisfied:

$$\sum_{i=0}^{m} \alpha_i = 0 \qquad \sum_{i=0}^{m-1} \sum_{j=0}^{i} \alpha_j = \sum_{i=0}^{n} \beta_i \neq 0$$

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SUBMITTED: October 28, 1957

Card 2/2

16(1)

AUTHORS: Budak, B.M. and Gorbunov, A.D. SOV/20-124-6-3/55

TITLE: On the Stability of the Calculation Processes Arising in the Solution of the Cauchy Problem for the Equation dy/dx= =f(x,y) With the Aid of Multipoint Difference Methods (Ob ustoychivosti vychislitel'nykh protsessov, voznikayushchikh pri reshenii mnogotochechnymi raznostnymi metodami zadachi Koshi dlya uravneniya dy/dx = f(x,y))

PERIODICAL: Doklady Akademii nauk SSSR,1959,Vol 124,Nr 6,pp 1191-1194(USSR)

ABSTRACT: The approximative solution of the problem

(1) $y' = f(x,y)$, (2) $y(x_0) = y_0$

is sought by means of the difference equation

(3) $\sum\limits_{i=0}^{m} \alpha_i y_{k-i} = h \sum\limits_{i=0}^{n} \beta_i f_{k+1-i}$, $f_j = f(x_j, y_j)$

for the initial conditions

(4) $y_o = g(x_o, h)$, $y_i = g(x_i, h)$.

If K is the class of the admissible functions f(x,y) and R(K) a certain method according to which the approximative

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On the Stability of the Calculation Processes SOV/20-124-6-3/55
Arising in the Solution of the Cauchy Problem for the Equation
dy/dx=f(x,y) With the Aid of Multipoint Difference Methods

solution y* is found with the aid of (3) and (4), then the totality (3),(4),R(K) is denoted as calculation process which arises in the solution of (1)-(2) by means of the difference method. In a very general way the "convergence of the calculation process" and its "stability of order k" is defined. In five theorems the relations between (uniform) convergence, the stability of order zero and one and the errors are formulated without proof. There are 6 references, 5 of which are Soviet, and 1 is Swedish.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet imeni M.V.Lomonosova (Moscow State University imeni M.V.Lomonosov)

PRESENTED: November 5, 1958, by S.L.Sobolev, Academician

SUBMITTED: November 3, 1958

Card 2/2

BUDAK, B.M.; GORBUNOV, A.D.

Many-point difference methods of solving Cauchy's problem for the equation $y' = f(x, y)$. Vest.Mosk.un.Ser.1: Mat., mekh. 16 no.4:10-19 Jl-Ag '61. (MIRA 14:8)

1. Kafedra matematiki fizicheskogo fakul'teta Moskovskogo gosudarstvennogo universiteta.
(Calculus, Differential) (Differential equations, Partial)

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C111/C444

AUTHORS: Gorbunov, A. D., Budak, B. M.

TITLE: Multipoint difference methods for the solution of Cauchy's problem in the case of the equation $y'=f(x,y)$

PERIODICAL: Akademiya nauk SSSR. Doklady, v. 140, no. 2, 1961, 291-294

TEXT: The Cauchy problem

$$y' = f(x,y), \quad (x,y) \in G, \quad G \text{ a domain} \tag{1}$$

$$y(x_0) = y_0, \quad (x_0, y_0) \in G, \tag{2}$$

is to be solved approximately by replacing it by the difference problem

$$\sum_{i=0}^{m} \alpha_i y_{k+i} = h \sum_{i=0}^{n} \beta_i f(x_{k+i}, y_{k+i}), \quad x_j = x_0 + jh, \quad h > 0; \tag{3}$$

$$y_i \approx y(x_i), \quad i = 0,1,\ldots, q-1 \tag{4}$$

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where $q = \max(m,n)$ is the order of (3). Let $f(x,y)$ belong to the class (A') if it is continuous in G and satisfies the Osgood condition in y. Let $\delta_i = y(x_i) - y_i$. Definition: The difference method (3), (4) converges unconditionally in the class (A'), if under arbitrary convergence to zero of $\max\limits_{0 \leqslant i \leqslant q-1} |\delta_i|$ for every $f(x,y) \in (A')$ an interval $x_0 \leqslant x \leqslant \bar{x}_f$ exists such that $\delta_i \rightrightarrows 0$ for $h \to 0$, $q \leqslant i \leqslant T_h$, where

$$T_h = \left[\frac{\bar{x}_f - x_0}{h}\right] - \frac{1}{2}\ \mathrm{sign}\ (n-m)\cdot\left[1 + \mathrm{sign}\ (n-m)\right].$$

Theorem 1: In order (3), (4) to converge unconditionally in (A') it is necessary und sufficient that

$$\sum_{i=0}^{m} \alpha_i = 0, \quad \sum_{i=0}^{m} i\alpha_i = \sum_{i=0}^{n} \beta_i \neq 0; \qquad (5)$$

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Multipoint difference methods for the... C111/C444

that all simple roots of the characteristic equation

$$\sum_{i=0}^{m-1} \sum_{j=i+1}^{m} \alpha_j \lambda^i = 0 \qquad (6)$$

have a modulus ≤ 1 and that all multiple roots of (6) have a modulus < 1.

If y_i^* is the approximative value of y_i obtained by round-off and if

$$\gamma_k = \sum_{i=0}^{m} \alpha_i y_{k+i}^* - h \sum_{i=0}^{n} \beta_i f(x_{k+1}, y_{k+i})$$

then the stability of the computation process is secured, if the condition (7) $|\gamma|_k \leq O(h)$ for $h \to 0$ is satisfied (Theorem 2).

Let $f(x,y) \in (A'')$, if $f(x,y)$ satisfying the Osgood condition in both arguments. Let $D_k = y(x_k) - y_k^*$.

Theorem 3: If all roots of (6) have a modulus < 1, $f(x,y) \in (A'')$ and

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(5), (7) are satisfied, then outside of an arbitrary small neighborhood of $x = x_o$

$$\frac{\Delta D_k}{h} \rightrightarrows 0 \text{ for } h \to 0 \qquad (8)$$

for an arbitrary convergence to zero of $\max\limits_{0 \le k \le q-1} |D_k|$. If besides $\Delta D_k/h \to 0$ for $h \to 0$, $k = 0,1,\ldots, q - z$, then (8) holds for $0 \le k \le T_n$. Theorem 4 brings estimations of $|D_k|$ for the case that $f(x,y)$ in G satisfies the Lipschitz condition with respect to both arguments $(f(x,y) \in (B_o))$. Similar estimations for the case that the derivatives of $f(x,y)$ satisfy certain Lipschitz conditions are brought in theorem 5. In conclussion to theorem 4 and 5 in certain cases there follows the uniform estimation $|D_k| \le O(h^s)$. In theorem 7 the special equation (3)

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$$y_{k+m} = \sum_{i=0}^{m-1} \alpha_i y_{k+i} + h \sum_{i=0}^{m} \beta_i f(x_{k+i}, y_{k+i}),$$

where $f_y(x,y) \leq 0$, is considered. The theorems 8 and 9 contain a posteriori estimations. Let $\bar{\theta}(x) = \bar{y}'(x) - f(x,\bar{y}(x))$, where $y=\bar{y}(x)$ is the equation of the polygonal line which connects the points (x_i, y_i^*), $i = 0,1,\ldots$,. Let $D(x) = y(x) - \bar{y}(x)$,

$$F^{(D)}(x) = \left[f(x,y(x)) - f(x,\bar{y}(x))\right]\left[y(x) - \bar{y}(x)\right]^{-1},$$

$$\bar{\theta}^{+}(x) = \begin{cases} \bar{\theta}(x) & \text{for } \bar{\theta}(x) \geqslant 0, \\ 0 & \text{for } \bar{\theta}(x) < 0, \end{cases} \qquad \bar{\theta}^{-}(x) = \begin{cases} 0 & \text{for } \bar{\theta}(x) \geqslant 0 \\ \bar{\theta}(x) & \text{for } \bar{\theta}(x) < 0 \end{cases}$$

Then it holds:

Theorem 8: For $D(x)$ there holds the estimation

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$$D(x)| \leqslant |D(x_0)| \exp\left[\int_{0_0}^{x} F^{(D)}(\xi)d\xi\right] + \left|\int_{x_0}^{x} \bar{\theta}(\eta)\exp\left[\int_{\eta}^{x} F^{(D)}(\xi)d\xi\right]d\eta\right|. \quad (10)$$

There are 7 Soviet-bloc and 2 non-Soviet-bloc references.

The reference to English-language publication reads as follows: V. E. Miln, Chislennoye resheniye differentsial'nykh uravneniy, JL, 1955 [Numerical solution of differential equations].

ASSOCIATION: Moskovskiy gosudarstvennyy universitet imeni M.V. Lomonosova (Moscow State University imeni M.V.Lomonosov)

PRESENTED: April 7, 1961, by S. L. Sobolev, Academician

SUBMITTED: April 7, 1961

Card 6/6

BUDAK, B.M.; GORBUNOV, A.D.

Multipoint method for solving Cauchy's problem for the equation y'=f(x,y). Vych. met. i prog. 1:19-46 '62. (MIRA 15:8)
(Difference equations)

TIKHONOV, A.N. (Moskva); GORBUNOV, A.D. (Moskva)

Asymptotic error expansion in the difference method for solving Cauchy's problem for a system of ordinary differential equations. Zhur.vych.mat.i mat.fiz. 2 no.4:537-548 Jl-Ag '62. (MIRA 15:8)
(Errors, Theory of) (Differential equations)

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TIKHONOV, A. N. (Moskva); GORBUNOV, A. D. (Moskva)

Optimality of implicit difference systems of the Adams type. Zhur. vych. mat. i mat. fiz. 2 no.5:930-933 S-O '62. (MIRA 16:1)

(Differential equations)

S/208/63/003/001/011/013
B112/B102

AUTHORS: Tikhonov, A. N., Gorbunov, A. D. (Moscow)

TITLE: Asymptotic estimates of error for a method of the Runge-Kutta type

PERIODICAL: Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki, v. 3, no. 1, 1963, 195-197

TEXT: Approximate solutions of the Cauchy problem

$$dy/dx = f(x,y),\ y(x_0) = y_0 \qquad (1)$$

by means of a formula of the Runge-Kutta type are considered. It is shown that the error satisfies the inequality

$$\|\delta_k\|_1 \leqslant O(h^s)\left[\int_0^{x_k-x_0} \exp \int NLd\xi + O(h)\right],$$

if the function f is continuous and has continuous derivatives of the s-th order. Asymptotic expansions of the error are derived.

SUBMITTED: April 9, 1962
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IJP(C)

AUTHOR: Gorbunov, A. D. (Moscow) and Shakhov, Yu. A. Tbilisi)

TITLE: An approximate solution of the Cauchy problem for ordinary differential equations with a preassigned number of exact signs. I

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PERIODICAL: Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki, v. 3, no. 2, 1963, 239-253

TEXT: The bilateral difference method by Ronge-Cutt for the approximate solution of the ordinary differential equations allows a simple and exact estimate of errors and is easier than the similar method by Adams since it does not contain the "initial section." The present paper investigates the abovementioned method for the case of first order differential equations with an emphasis on the particularities related to approximate quadratures (the approach follows three steps: the evaluation of the quadratures, Cauchy's problem for one equation, and Cauchy's problem for a system of equations). The authors derive the bilateral methods for the first, second, and third order. Each pair of equations depends on two parameters whose choice specializes the method to suit any particular problem. Using the computer Strela of the Moscow State University Computing Center, the authors numerically calculated tables for the functions (1) $y' = y$, $y(0) = 1$ with the third order method; (2) $y' = -y/x$, $y(1) = 1$ with the second order method; (3) the Fresnel

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integral using the third order method with a limiting error of $6 \cdot 10^{-8}$ and (4) $\int_0^{8.95} dx/(1 + x)$ with a preassigned accuracy and two exact signs. The authors thank A. N. Tikhonov and I. S. Berezin for their interest. There are 7 tables.

SUBMITTED: May 19, 1962

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ACCESSION NR: AT4047142 S/0000/64/000/000/0135/0148

AUTHOR: Gorbunov, A. D. (Moscow); Popov, V. N. (Moscow)

TITLE: Adams-type methods for an approximate solution of the Cauchy problem for ordinary differential equations with delay

SOURCE: Chislenny*ye metody* resheniya differentsial'ny*kh i integral'ny*kh uravneniy i kvadraturny*ye formuly* (Numerical methods of solving differential and integral equations and quadrature formulas); sbornik statey. Moscow, Izd-vo Nauka, 1964, 135-148

TOPIC TAGS: Cauchy problem, generalized Adams formula, differential equation with delay, approximate method

ABSTRACT: This article deals with an approximate solution of the Cauchy problem

$$\frac{dy(x)}{dx} = f\left(x, y(x), y(x-\tau(x))\right)$$

$$y(x) = \phi_0(x)$$

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where f is a sufficiently smooth curve defined in a certain closed domain of three-dimensional space, $\tau(x)$ (delay) is a given positive and sufficiently smooth function, and $\phi_0(x)$ is a sufficiently smooth function defined on a certain set of initial values. It is pointed out that there is some possiblity that the approximate solution $y(x)$ has weak discontinuities (discontinuities of the first kind of its derivative) and, therefore, "high accuracy" formulas of the Adams or Runge-Kutta type can not be applied directly to the solution of this problem, and certain modifications of these formulas are necessary. Formulas for interpolating a function with discontinuous derivatives are derived which serve as the basis for constructing generalized formulas of the Adams type, and the algorithm of their application to the solution of the given problem is presented. It is stressed that the method developed can also be applied to the solution of Cauchy lems for classical ordinary differential equations with discontinuous right hand sides, for the neutral type of equations, and for other analogous cases. The convergence of generalized methods of the Adams type is proved, and an estimate of the computation error is established The derived results are extended to a system of equations. The algorithms for solving the Cauchy problem for a system of equations

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with a delayed argument and for interpolating functions with discontinuous derivatives are written in ALGOL-60 language. Two numerical examples illustrate the integration procedure. Orig. [illegible] [illegible] formulas.

ASSOCIATION: none

SUBMITTED: 20Apr63 ENCL: 00 SUB CODE: [illegible]

NO REF SOV: 010 OTHER: 001 ATD PRESS: 3138

Card 3/3

ACCESSION NR: AP4024557 S/0208/64/004/002/0232/0241

AUTHORS: Tikhonov, A. N. (Moscow); Gorbunov, A. D. (Moscow)

TITLE: Error estimate in Runga-Kutta method and optimum mesh selection

SOURCE: Zhurnal vy*chislitel'noy matematiki i matematicheskoy fiziki, v. 4, no. 2, 1964, 232-241

TOPIC TAGS: optimum mesh size, Runga-Kutta method, Cauchy problem, vector-function, asymptotic expansion

ABSTRACT: A method for selecting optimum mesh size in the Runga-Kutta method of solving the Cauchy problem has been discussed. The system of ordinary differential equations considered is represented by

$$\frac{dy}{dx} = f(x, y), \qquad y(x_0) = y_0,$$

where f- is a given vector-function of N + 1 variables, smooth and continuously differentiable in a closed domain G. The functional distribution and various parameters of mesh size are introduced, forming an ensemble and representing an

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irregular array. An asymptotic expansion is obtained for the modulus of error, using the elements of irregular mesh representation. This is given by

$$v(x) = \lambda^s C \int_{x_0}^{x} \Xi(\xi, x)\bar{\psi}(\xi, y(\xi))\varphi^s(\xi)\,d\xi + O(\lambda^{s+1}),$$

where Ξ - matrizant of matrices A(x); λ - positive number; φ - normal mesh size distribution function; ψ - a well-defined operator on f. Finally, the solution is given for selecting optimum mesh size. For N = 1, this is accomplished by minimizing the modulus of the principal term in the above equation for the error estimate. The mesh distribution function is then calculated, using an integration process. A similar method is used for N>1 by selecting some "preferable" coordinate or a "norm" of the principal term in the asymptotic expansion of the error modulus. Orig. art. has: 53 equations.

ASSOCIATION: none

SUBMITTED: 12Jul63 DATE ACQ: 16Apr64 ENCL: 00

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Card 2/2

ACCESSION NR: AP4037248 S/0208/64/004/003/0426/0433

AUTHORS: Gorbunov, A. D. (Moscow); Shakhov, Yu. A. (Tiflis)

TITLE: Approximate solution of the Cauchy problem for ordinary differential equations with previously given number of correct signs. 2.

SOURCE: Zhurnal vy*chislitel'noy matematiki i matematicheskoy fiziki, v. 4, no. 3, 1964, 426-433

TOPIC TAGS: approximate solution, Cauchy problem, differential equation, correct sign, Runge Kutta method

ABSTRACT: Let $y(x) = \{y^{(1)}(x),\ldots,y^{(N)}(x)\}$ be the desired vector-function, of N dimensions, $f(x,y) = \{f^{(1)}(x,y),\ldots,f^{(N)}(x,y)\}$ be a given vector-function of N + 1 variables $x,y^{(1)},\ldots,y^{(N)}$, continuous and sufficiently smooth in some closed region G of the space $\{x,y^{(1)},\ldots,y^{(N)}\}$, $(x_o,y_o) \in G$. The authors consider the Cauchy problem for the system of differential equations

$$\frac{dy}{dx} = f(x, y), \quad y(x_0) = y_0, \qquad (1)$$

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They describe coordinate-wise two-sided Runge-Kutta methods for approximate solution of (1) and give expressions for the remainder terms in the general case. They prove convergence of the Runge-Kutta methods, study the concept of measure of error of the approximate solution, and derive an effective estimate of the modulus of this measure. The conditions of computation under which the approximate solution is obtained with a given number of correct signs are explained, and some numerical results are given. This paper is a generalization of the authors' previous work (same title, No. I.). "The authors express their deep gratitude to A. N. Tikhonov, I. S. Berezin and D. A. Kveselav for their constant attention to the work." Orig. art. has: 4 tables and 20 formulas.

ASSOCIATION: none

SUBMITTED: 05Jun63 DATE ACQ: 09Jun64 ENCL: 00

SUB CODE: MA NO REF SOV: 004 OTHER: 000

Card 2/2

BAKUSHINSKIY, A.B.; GAYSARYAN, S.S.; GORBUNOV, A.D.

"Numerical solution of ordinary and partial differential equations" edited by L. Fox. Reviewed by A.B. Bakushinskii. Zhur. vych. mat. i mat. fiz. 4 no.3:615-617 My-Je '64. (MIRA 17:6)

GORBUNOV, A.D. (Moskva); POPOV, V.N. (Moskva)

Adams type methods for approximate solution of the Cauchy problem for ordinary differential equations with retardation. Zhur. vych. mat. i mat. fiz. 4 no.4(suppl.):135-148 '64.

(MIRA 18:2)

$$y_{k+1} = y_k + h \sum_{i=0} \gamma_i f(x_{k+i}, y_{k+i}),$$

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